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The beds thus formed were built up very slowly, and when completed and solidified were so compact and fine grained as to be nearly or quite impermeable to liquids from the outside. If infiltrated by any material from without before the water originally included was drained and dried away, it is difficult to see how this could be done by liquids lighter than water, coming into it in the form of a uniform seepage from below. Exactly contemporaneous with the gradually progressive disappearance of the water and the chemical changes accompanying this, the sediments were compacted, solidified and lithified to their present texture and condition, and it seems highly probable that penetration by liquids from any outside source during the induration would be increasingly difficult. If these views are correct, the gaseous and liquid compounds obtained by distillation from the shale are not of external origin, but result from the decomposition of the carbonaceous material laid down during the formation of the rock. The absence of demonstrable liquid hydrocarbons in the shale itself would tend to strengthen this view, although not an insurmountable objection.

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ARCHEOLOGICAL EXPLORATIONS AT PECOS, NEW MEXICO

By A. V. Kidder

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Received by the Academy, February 1, 1916

During the past summer the Department of Archaeology of Phillips Andover Academy began the excavation of the ruined Indian Pueblo of Pecos in San Miguel County, New Mexico. It was the wish of the Department to undertake the thorough exploration of a site large enough and of sufficient scientific importance to justify work upon it for several years.

Pecos lies in the well-watered and fertile upper Pecos valley at an elevation of about 7000 feet. The buildings are located on the summit of a flat-topped ridge of sandstone slightly elevated above the surrounding plain, and consist of two house-clusters containing together, as nearly as can be made out in their present state of ruin, about 1100 ground floor rooms. A few hundred feet to the south stand the roofless walls of the large Spanish mission church.

The place was discovered by Coronado in 1540. At that time it was the most populous of the Pueblo villages, being able to muster 500 fighting men. The chroniclers of the expedition describe the town as a quadrangular structure, four stories in height, on the balconies of which one could make the entire circuit without putting foot to ground. The people were brave, prosperous and skilled in all the arts of the Pueblos. After Coronado, Pecos was visited by several other explorers and when New Mexico was actually settled by the Spanish at the beginning of the seventeenth century Pecos was made the seat of a mission, a large church was erected and the town became one of the most important and prosperous in the province. During the eighteenth century, however, its position on the eastern frontier exposed it to ever-increasing raids by the Comanche. Thus worn down and greatly reduced by sickness, the Pecos people managed to hold out until about 1840 when, numbering only seventeen souls, they abandoned their home and put themselves under the protection of the Jemez, a nearby tribe related to them by language and tradition.

We have, then, a historically recorded occupation from 1540 until 1840; and an examination of the potsherds scattered about the ruins shows also practically all the types of prehistoric wares known to occur in the upper Rio Grande district. The Department therefore believed that the site had been settled in very early times and that people had lived there, presumably continuously, through all the intervening centuries. So long an occupation does not seem to have occurred at any other place in New Mexico available for excavation and it was hoped that remains would there be found so stratified as to make clear the development of the various Pueblo arts and to enable students to place in their proper chronological order numerous New Mexican ruins whose culture has long been known but whose relation one to another has been entirely problematical. This hope was strengthened by the fact that Mr. N. C. Nelson of the American Museum, New York, had recently discovered very important stratified remains at San Christobal a few miles to the west and it was believed that, if similar deposits could be found at Pecos, they would serve not only to complement and, so to speak, cross-reference the finds of Mr. Nelson, but also to carry the story of Pueblo arts from 1680, the date of the abandonment of San Christobal, down through the very little known eighteenth century to the middle of the nineteenth, from which time to the present day it may still be recovered by studies among the living tribes. These were the chief reasons for the choice of Pecos.

The Regents of the State Museum of New Mexico, in whom the title to the ruins is vested, requested in making their very generous offer of the site, that the old church, greatly damaged by the weather and by vandalism, and in imminent danger of entire collapse, be so repaired and protected that no further harm should ensue. This work was cheerfully undertaken and was carried out during the summer by Mr. J. L. Nussbaum of Santa Fé; the body of the church was cleared, the walls strengthened and underpinned, and fallen portions of several arches, doorways and windows were replaced.

The archaeological work consisted entirely of excavations in the great rubbish heap on the east side of the mesa. Digging was commenced there because it was necessary to clear a place in which earth and stone, removed from the houses above, could later be dumped without danger of covering unexplored ground. This portion of the work continued longer than was expected because of the unforeseen depth and extent of the rubbish deposit. This miscalculation of the mass of the rubbish was due to the mistaken belief that the terrace surrounding the building proper formed part of the solid rock mesa (fig. 1). When, however, the trenches reached the defensive wall supposed to mark the end of the midden, it was found that the terrace, instead of being rock, was composed entirely of rubbish (fig. 2) thus approximately doubling the amount to be handled. Further complications were encountered in the form of buried kivas and old defensive walls, so that at the end of the season the main trench face was still some distance away from the

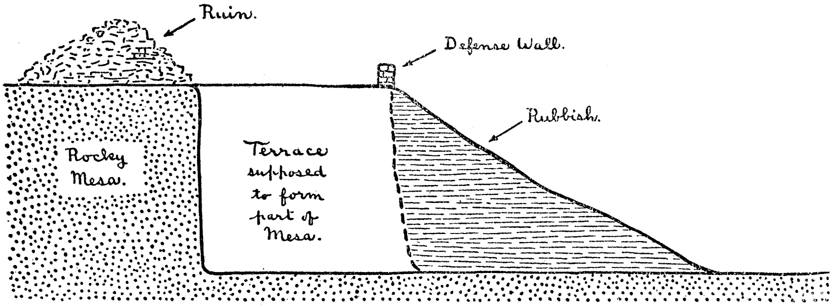

FIG. 1. SUPPOSED EXTENT OF RUBBISH BEFORE EXCAVATION

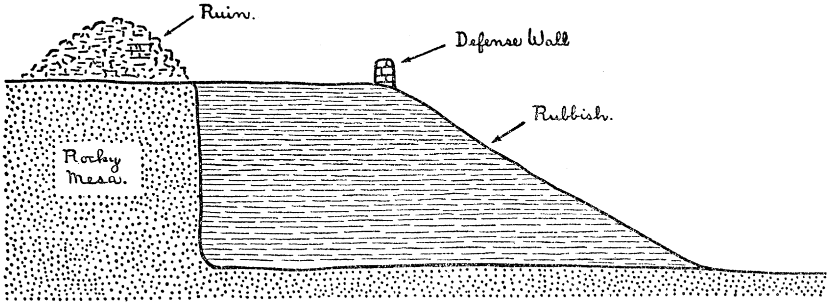

FIG. 2. ACTUAL EXTENT OF RUBBISH

mesa. Three narrow exploring trenches, however, were pushed through the terrace to the rock wall.

Against the mesa the deposit was found to vary from 15 to 20 feet in depth. It sloped away gradually toward the plain. Its composition was very uniform, soft earth darkened by charcoal and decayed organic matter, filled with potsherds, animal bones and chips of building stone. The heap was also used as a cemetery, our trench revealing over 150 burials; the skeletons lay, for the most part, in the flexed position, at depths varying according to the period of interment of from a few inches to 17 feet. Mortuary pottery occurred only in the earlier graves and not abundantly even in them. Besides skeletons and pottery there were recovered a great number of broken and many whole specimens of bone and stone tools, as well as ornaments, clay toys and figurines.

The most important results, however, were, as had been hoped, of a stratigraphical nature. It became apparent, as soon as digging had gone far enough into the refuse heap to permit observations, that the pottery at the bottom was markedly different from that at the top and that there were several distinct types between. Data on this subject were collected to some extent by examination and note taking along the face of the trench, but principally by tests made at different points as the work advanced. The tests consisted of the collection of all the sherds in a given column of débris, the fragments from each layer being placed in a separate paper bag bearing the numbers of the test and of the layer. In the early tests the face was laid off arbitrarily in 1 foot or 18 inch layers; but as it was found that this method often resulted in the splitting of strata, the later tests were not laid out beforehand and a new bag was started whenever there was encountered a zone of sand or ash or when there appeared a sherd different in type from those above. Care, of course, had to be exercised to choose for the tests places which seemed to contain no burials, and all trials were abandoned when it became clear that a grave shaft had disturbed the original deposition of the refuse.

The mass of stratigraphic material thus gathered could not be worked over in the field; final results, therefore, are not yet available. It may be said, however, that the earliest or lowest type was the black-and-white. Above this occurred a long series of wares with glazed ornamentation, running from an early type with clear cut geometric ornament in sharp glaze, up through more developed stages having heavier glaze and conventional ornament, to a late and degenerate style in which the glaze paint was so poor that the decoration lost all form and became little more than daubs and splashes. This degenerate stage extended well into historic times, as was proved by the finding, in that horizon, of European objects, but before the final abandonment of the site there occurred a sort of renaissance, when glaze painting was given up and there was produced a yellowish pottery excellently finished and tastefully decorated with dull black pigment.

The details of this long ceramic history; the growth, for example, of vessel forms; the developments in the cooking wares; the influences from without that undoubtedly produced some of the changes; all these must await closer study and more data.

The stratigraphy of the site, then, throws invaluable light on the local culture; it also may be expected to teach us much as to its external relations. In the first year's work there has been found pottery of the historic period from the Hopi villages, Acoma, Zuni, and Jemez, as well as prehistoric wares from the Little Colorado, Lower Gila (?), and San Juan. From the East we have pottery, buffalo-scapula hoes and snubnosed scrapers; from the South, clay bells and spindlewhorls strongly Mexican in type. Such finds as these give an indication of what important results may confidently be hoped for. If we can definitely recognize and chronologically arrange the successive culture stages at Pecos, we can extend that knowledge and thus fit into their proper chronological order the one-culture ruins that abound in the Rio Grande. We may also hope to learn, from trade objects found at Pecos and in the chronologically arranged one-culture ruins, the relative age of many other groups, not only in the Southwest but even well beyond its borders.

MAN AND METALS

By Walter Hough

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Received by the Academy, January 24, 1916

In the course of a long-continued study of the uses of fire by man, I have recently completed a review of the branch referring to metallurgy, the results of which are embodied in the following brief summary.

The free metals which early man might have found and used are copper, gold, and silver. It is known that he used copper, and to some extent silver and gold, and that he worked them as other hard substances, becoming gradually acquainted with the property of ductility of these metals. Since copper was the most common metal in a free state and potentially at an early stage the most useful, it is safe to say that its employment was the beginning of the age of metals. Strictly,